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ABSTRACT

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DIAGNOSIS OF INTERNAL ROOT RESORPTION: CLINICAL MANIFESTATIONS AND RADIOLOGICAL FEATURES

Introduction. There are several types of internal tooth resorption, each of which has its own etiology, pathogenesis, clinical signs and radiological features. Each type of resorption can have serious consequences for the tooth and surrounding tissues, so it requires timely and accurate diagnosis, specific treatment strategies, observation and monitoring. The study aimed to represent the clinical manifestations and diagnostic peculiarities of internal root resorption, enabling practicing dentists to timely diagnose lesions and take appropriate measures to avoid further complications.

Methods. Patients with internal inflammatory root resorption (n=8) and with internal replacement resorption (n=7) were included in the study. The groups were analyzed according to clinical and radiological parameters. Pulp vitality was determined by standard examination methods (inspection, probing, percussion, sensitivity test, EOD). When evaluating X-ray images, the size, localization and contours of the resorption of hard tooth tissues and/or bone destruction, periapex, the quality of filling the root canals were considered.

Results. Affected teeth with partially vital pulp have caused symptoms and/or signs of acute or chronic pulpitis. Internal inflammatory and internal replacement types of resorption in depulped teeth had similar clinical signs: asymptomatic course, tooth color change; lesions of resorption were detected accidentally during radiographic examination. The majority of the teeth with internal root resorption did not have prior endodontic treatment (86.7%) and had a normal periapex (60.0%). In 14.3% of cases with internal replacement resorption some ankylosis with reduced mobility was revealed. Most of the affected teeth were anteriors (53.3%), internal resorption lesions were mainly located in the middle (50.0%) and the lower thirds of the root (37.5%). Radiographically, in inflammatory resorption a symmetric oval-shaped radiolucent enlargement of the root canal with

smooth and well-demarcated margins was found; in case of replacement resorption, a round-shaped (ballooning) radiolucency enlargement with an irregularly (cloudy) and/or mottled inclusions of bone-like tissue was detected.

Conclusions. Early diagnosis, elimination of the cause, timely management of root resorption are mandatory for tooth preservation. The main method of diagnosis of internal tooth resorption is radiographic, as the process can proceed without subjective painful sensations. The leading role belongs to dental computer tomography. One of the radiological criteria of pathological tooth resorption is a change in the internal configuration of the root canal.

Keywords: tooth root, root resorption, internal resorption, inflammatory resorption, replacement resorption, resorption diagnosis.

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ДІАГНОСТИКА ВНУТРІШНЬОЇ РЕЗОРБЦІЇ КОРЕНЯ ЗУБА: КЛІНІЧНІ ПРОЯВИ ТА РЕНТГЕНОЛОГІЧНІ ОСОБЛИВОСТІ

Вступ. Розрізняють декілька типів внутрішньої резорбції кореня зуба, кожен з яких має свою етіологію, патогенез, клінічні та рентгенологічні особливості. Кожен вид резорбції може мати серйозні наслідки для зуба і навколишніх тканин, тому потребує своєчасної та точної діагностики, специфічних стратегій лікування, спостереження та моніторингу. Метою дослідження було представити клінічні прояви та діагностичні особливості внутрішньої резорбції кореня зуба, що дасть змогу практикуючим лікарям-стоматологам своєчасно виявити ураження та вжити відповідних заходів для уникнення подальших ускладнень.

Методи. В дослідження включали пацієнтів із внутрішньою запальною резорбцією кореня зуба (n = 8) та з внутрішньою замісною резорбцією кореня (n = 8). Групи були проаналізовані за клінічними та рентгенологічними показниками. Життєздатність пульпи визначалась стандартними методами обстеження (огляд, зондування, перкусія, температурна проба, ЕОД). При оцінці рентгенологічних знімків враховували розмір, локалізацію та контури деструкції твердих тканин зубів та/чи деструкції кістки; стан періодонтальної щілини, якість пломбування кореневих каналів зубів.

Результати. Уражені зуби із частково життєздатною пульпою викликали симптоми та/або ознаки гострого чи хронічного пульпіту. Внутрішньо запальний та внутрішньо замісний типи резорбції в депульпованих зубах мали схожі клінічні ознаки: безсимптомний перебіг, зміна кольору зуба; ділянки резорбції виявляли випадково при рентгенографічному дослідженні. Більшість зубів із внутрішньою резорбцією не мали попереднього ендодонтичного лікування (86,7%) і мали рентгенологічно здоровий періодонт (60,0%). При внутрішньо замісній резорбції в 14,3% випадків виявлено анкілоз зі зниженою рухливістю зуба. Більшість уражених зубів були передніми (53,3%), ураження

внутрішньої резорбції переважно розташовувалися в середній (50,0% випадків) та нижній третині кореня зуба (37,5%). Рентгенологічно при запальній резорбції зазвичай виявляли симетричні рентгенопрозорі розширення кореневого каналу овальної форми з гладкими та добре обмеженими краями, при замісній резорбції – розширення кореневого каналу округлої форми з нечіткими та/або плямистими включеннями остеїдоподібної тканини.

Висновки. Рання діагностика, усунення причини, своєчасне лікування резорбції кореня зуба є обов'язковими для збереження зуба. Основним методом діагностики внутрішньої резорбції є рентгенологічний, так як процес може протікати без суб'єктивних болочих відчуттів. Провідна роль належить дентальній комп'ютерній томографії. Одним із рентгенологічних критеріїв патологічної резорбції кореня зуба є зміна внутрішньої конфігурації кореневого каналу.

Ключові слова: корінь зуба, внутрішня резорбція, резорбція кореня, запальна резорбція, замісна резорбція, діагностика резорбції.

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INTRODUCTION / ВСТУП

Root resorption of a permanent tooth is a pathological process characterized by the progressive loss of dentin, cementum and bone tissue surrounding the tooth [1, 2]. Dentin is lined internally from the pulp surface with odontoblast layer and predentin, and externally from the periodontal ligament with a layer of cementoblasts and cementum [3, 4]. Both layers form a barrier that prevents resorption and adhering of osteoclasts on the unmineralized dentin matrix [5]. In case of violation of the development of predentin and cementum, or as a result of infection or their mechanical damage, osteoclasts accumulate on the unprotected dentine surface, that causes resorption [6].

Root resorption is polyetiological, most often has no pathognomonic signs; it is characterized by a sluggish, asymptomatic course [7]. The causes of resorption are various, among them tooth trauma, bruxism, endodontic and periodontal diseases, dental bleaching, it can occur after coronal pulp amputation and capping the root pulp with calcium hydroxide, as a result of treatment with braces or other orthodontic appliances, which is associated with aggressive and rapid tooth movement, and also in the presence of specific diseases and disorders: genetic disorders and hereditary diseases, endocrine pathology, disorders of osteogenesis processes, after radiation therapy, etc. [8, 9, 10].

Depending on the etiological factor, there are odontogenic resorption (transient; apical inflammatory; cervical inflammatory; resorption resulting from tumors or jaw cysts) and non-odontogenic, caused by systemic disorders [5]. The classification of tooth resorption depending on the process localization in the root and further subclassification by pathogenesis [6] is as follows: external – on the outer root surface (surface, inflammatory, replacement, cervical, transient apical breakdown) and internal – in the root canal (inflammatory, replacement).

External tooth resorption is more common (from 20%), the frequency of manifestations of internal root resorption in the dental practice occurs less often (from 0,1 to 9.6%) [11], therefore certain difficulties may arise in diagnosis and in choosing the correct treatment strategy. Internal root resorption can develop rapidly, destroying the tooth in a few months, or may last for years without pronounced pathological activity [7, 12]. A gradual increase of defect sizes leads to a root fracture, and, accordingly, to the fragments removal [13]. In the diagnosis of internal root resorption in the absence of clinical symptoms, traditional radiography and cone beam computed tomography (CBCT) occupy a prominent place [2, 6, 11].

In endodontic practice, root resorption of a permanent tooth is prognostically unfavorable,

because it can be accompanied by an irreversible loss of a significant amount of hard tooth tissue, therefore it requires timely diagnosis and effective management. Nonsurgical therapy of resorption is based on adherence to a standard endodontic protocol. In the first visit, after instrumental treatment of root canal with nickel-titanium systems [3], removal of resorption tissue with the help of ultrasonic instruments and thorough irrigation of the root canal with ultrasonic activation of sodium hypochlorite [14], a temporary filling of the root canal is carried out using an antibiotic-corticosteroid paste (e.g. Ledermix), if the resorption is active, followed by calcium hydroxide [15]. In patients with internal root replacement resorption, endodontic ultrasonic files and/or tips to navigate through the osteoid-like hard tissue are additionally used. On the second re-call the repeated instrumental treatment of the root canal system and ultrasonic irrigation are carried out, followed by obturation of the root canals with thermoplastic gutta-percha techniques. In the case of root canal perforation sealers based on mineral trioxide aggregate (MTA) or calcium silicate-based material (Biodentine) or Bioceramics are used for filling resorptive defects [5, 16, 17]. In patients with a significant loss of dentin and predentin in the root (more than 50%), the dentin defect is closed with MTA, the root canal system is obturated using a combined filling technique: the apical part of the root below resorption lesion is filled by lateral compaction method, above resorption lesion with hot gutta-percha [2]. Compliance with all of the above allows to increase treatment effectiveness of internal root resorption.

Thus, internal root resorption is a rare, insidious, resorptive pathological process that can have serious consequences for the tooth and surrounding tissues, therefore it requires timely and correct diagnosis, specific treatment strategies, follow-up and monitoring, that determines the research relevance.

The aim of the study is to familiarize clinicians with the clinical manifestations, radiological signs, and diagnostic peculiarities of pathological internal root resorption, which will enable practicing dentists to timely diagnose, aid the management of root resorption lesions and take appropriate measures to avoid further complications in everyday practice.

MATERIALS AND METHODS

The study represents the results of the examination of 15 patients aged 25–65 years old with internal root resorption (K03.3 to ICD-10). These patients applied to the Department of Therapeutic Dentistry during the last 3 years (2021-2023), where research results were

processed. Clinical and X-ray (conventional radiography, orthopantomogram, CBCT) research methods were evaluated. On the basis of clinical and radiological signs, patients with non-perforating internal root resorption of odontogenic origin were divided into 2 groups. The first group included 8 patients with internal inflammatory root resorption, the second group included 7 patients with internal replacement resorption. The groups were analyzed according to clinical and radiological indicators. Pulp vitality was determined by standard examination methods: probing of hard tooth tissues, percussion, sensitivity testing (freeze test), EOD. When evaluating X-ray images, the following parameters were taken into account: size, localization and contours of inflammatory destruction of hard dental tissues and/or bone destruction; condition of periodontal ligament space, the quality of root canal filling of the teeth located in the inflammation zone.

Statistical analysis of the study results was carried out using computer programs Microsoft® Excel 2017 for Mac and the licensed package “Statistica 6.1”. The critical level of significance in statistical hypotheses testing in this study was taken as equal to 0.05. Clinical symptoms and abnormalities during dynamic observation were recorded, but not subjected to statistical analysis.



Figure 1 – Periapical radiograph of tooth 21 with internal tooth resorption and apical periodontitis following orthodontic treatment

All examinations were performed on the basis of the principle of voluntary informed consent and do not contradict the main bioethical norms of the Helsinki Declaration. The research protocol was approved by Biomedical Ethics Committee of National Pirogov Memorial Medical University, Vinnytsya. The performed study is a component of research work of the Department of Therapeutic Dentistry “Clinical and laboratory substantiation of improvement the methods of diagnosis, treatment, prognosis and prevention of dental diseases”, state registration No. 0124U000174.

RESULTS

Most of the affected teeth with internal root resorption were anteriors (8/15, 53.3%), followed by molars (6/15, 40.0%) and premolars (1/15, 12.5%). The prevalence of resorption prevailed among men (66.7% vs. 33.3%, $p < 0.05$), the average age of patients was 48.1 ± 2.86 years. The majority of teeth with internal resorption had no previous endodontic treatment (13/15, 86.7%) and had a normal periapex (9/15, 60.0%).

In the 1st group of patients with inflammatory

non-perforating internal root resorption, there were no complaints, or they were typical for pulpitis or apical periodontitis; in anamnesis were pulpal trauma, in some cases – prior endodontic (25%) and orthodontic (12.5%) treatment (Figure 1). Affected teeth with partially vitality pulp (5/8, 62.5% of cases) caused signs and/or symptoms of acute or chronic pulpitis. Acute and chronic apical periodontitis was diagnosed in 3 cases (37.5%) of internal root resorption; slightly painful percussion and swelling of the mucobuccal fold (12.5%) and tooth discoloration were clinically revealed. Oval- or round-shaped enlargement of the root canal (ballooning) radiolucency was detected during radiographic examination of internal inflammatory resorption, which spreads symmetrically in all directions into the dentin surrounding the pulp and have clearly demarcated margins without radiographic root delineation in the defect (Figure 2). According to CBCT data, it was found that lesions of internal resorption were mainly located in the middle (4/8, 50.0% of cases) and the lower thirds of the tooth root (3/8, 37.5% of cases).

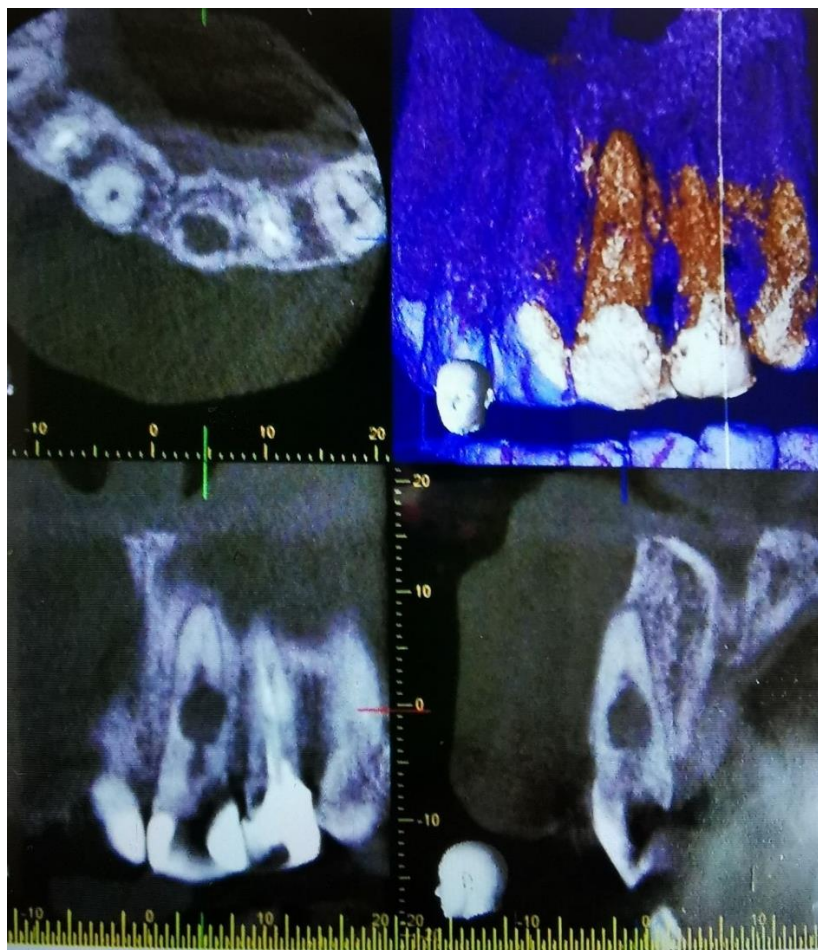


Figure 2 – Internal root resorption of tooth 21. CBCT is preferable to exclude root perforation

Clinical signs and symptoms of internal replacement resorption in the II group of patients were similar to internal inflammatory root resorption (Table 1). When determining pulp vitality, partial (57.1%) or complete (42.9%) necrosis was revealed. In 14.3% of cases (1/7), the tooth had some ankylosis with reduced mobility and a typical ankylotic percussion sound. Internal inflammatory and internal replacement types of root resorption in depulped teeth also had similar clinical signs: asymptomatic course, tooth color change; foci of resorption were found accidentally during radiographic examination. Radiographically, these resorptive defects and the adjacent root canal wall mostly had a patchy

appearance due to the inclusion of hard bone-like tissue. When analyzing CBCT with the presence of internal replacement tooth resorption, special attention was paid to periapical changes, because the presence of signs of apical periodontitis (widening of the periodontal ligament, resorption foci with even or uneven contours) indicated long-term endodontic pathology. CT scan sections of teeth revealed calcified tissue in the affected zone. The following parameters of the teeth were taken into account: root canal treatment, presence of periapical changes, presence of carious cavities / fillings, as well as periodontal changes (Table 2).

Table 1 – Clinical signs and symptoms of different types of internal root resorption

Feature	Internal inflammatory resorption	Internal replacement resorption
Clinical appearance	The affected tooth is healthy (vital), discoloured (necrotic), or have a pink spot in crown (rare); signs of pulpitis or apical periodontitis	The affected tooth will usually appear normal – healthy (vital), it may be discolored (necrotic) or have a slight pink hue (rare); signs of pulpitis or apical periodontitis
Clinical finding (features)	Asymptomatic (early), discolouration, symptoms of irreversible pulpitis and/or apical periodontitis (advanced), may have tenderness over apex	Symptoms of irreversible pulpitis and/or apical periodontitis; the tooth may have tenderness over apex or some ankylosis with reduced mobility
Root localization	Anywhere	Anywhere
Pulp sensitivity (thermal or electric)	Maybe positive in partially vital cases, or tooth may be respond negatively to sensitivity testing with advanced necrotic lesions	Maybe positive in partially vital cases, or negative in advanced necrotic cases
Radiological appearance	Resorption lesion is in the root canal. Oval shaped enlargement of root canal with smooth and well demarcated margins/ ballooning out of the existing root canal, which spreads symmetrically in all directions into the dentin surrounding the pulp. When the radiographs are taken at different angles, the radiolucent defect moves with the root canal.	The focus of destruction is in the root canal. Oval (round) shaped (ballooning) enlargement of root canal but with cloudy and/ or mottled canal wall inclusions of bone-like tissue. When the radiographs are taken at different angles, the radiolucent defect moves with the root canal.
Root canal	Canal expands into lesions	Canal expands into lesions

DISCUSSION

Root resorption is associated with physiological and pathological factors and leads to loss of dentin, cementum or bone tissue [1]. Regardless of localization, root resorption is irreversible, requires treatment, and/or, in some cases, leads to premature loss of the affected tooth [18, 19]. Diagnosis and

management of internal root resorption have been a challenge to dental practitioners.

Three types of internal tooth resorption are distinguished – surface, inflammatory and replacement. Internal surface resorption, described in a comprehensive review by Abbot P. V. & Lin S. [12], was not included in our study, as it is a rare condition defined as minor and shallow areas of

resorption of the dentin walls of the root canal. Clinically and radiographically, this type of resorption cannot be detected, since it occurs on the walls of the root canal [15]. The authors consider that this is a temporary and self-limited process, and the term “surface” is used to refer to this type of resorption, as it indicates a slight and superficial (shallow) nature of the resorption, which may be a precursor to internal inflammatory root resorption.

Among the examined patients with tooth root resorption, the etiological factors were pulpal infection, trauma, previous endodontic and orthodontic treatment. Internal resorption usually occurs as a result of a long-term chronic inflammatory process, after the loss of protective predentin

combined with continuous bacterial stimulation [10, 20]. The progress of internal resorption depends on the presence of vital pulp at / below the resorption zone and partially or completely necrotic pulp, coronal to the resorption site, which allows constant penetration of microorganisms and their antigens into the root canal [4, 21]. An important factor for the persistence of resorption is microbial stimulus. Bacteria may penetrate the dentine-pulp complex through dentinal tubules, carious lesions, broken-down restoration margins, along fracture lines or lateral canals [22]. After damage or irritation of the noncollagenous layer, odontoclasts are involved in the foci of damage or irritation by the release proinflammatory cytokines [19].

Table 2 – Additional signs were found when evaluating X-ray data with internal root resorption

Group	Prior endodontic treatment		The presence of fillings		Carious cavity		Periapical changes		Changes in the periodontium	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
I group	2/8	6/8	5/8	3/8	4/8	4/8	3/8	5/8	0/8	8/8
	25%	75%	62.5%	37.5%	50%	50%	37.5%	62.5%	0	100%
II group	1/7	6/7	5/7	2/7	3/7	4/7	3/7	4/7	1/7	6/7
	14.3%	85.7%	71.4%	28.6%	42.9%	57.1%	42.9%	57.1%	14.3%	85.7%

Note: the number of teeth with a detected sign / the number of patients in the group

Internal root resorption begins along the wall of the root canal and may consist of only granulation tissue in inflammatory internal root resorption or with granulation and osseous tissues in replacement internal root resorption [20]. Internal inflammatory resorption involves only the loss of intraradicular dentin without further deposition of hard tissue on the resorptive defects. In internal replacement resorption, the loss of intraradicular dentin is usually accompanied by the deposition of metaplastic bone or cementum-like hard tissue instead of dentin in the resorption lesions [19]. Internal root resorption may progress and potentially lead to root perforation/fracture [13], contributing to the formation of lateral or periodontal lesion [12] or apical periodontitis [14, 23] when the entire root canal system is infected with microorganisms.

Internal pathological resorption of the tooth root was mainly diagnosed in the frontal teeth, that is consistent with the literature data, in which this pattern is explained by the peculiarity of the collateral blood supply of this group of teeth, the anatomical structure of the incisors and canines, namely, the

presence of a wide apical foramen and lateral canals in them [11]. Several factors contribute to internal resorption development: the presence of inflammation in the coronal pulp, caused by caries and its complications (acute or chronic pulpitis), and abundant blood supply in the middle or apical part of the root canal. This combination promotes chronic inflammation of the pulp with enhanced migration of immune cells into the root canal system, activation of odontoclasts and prevents classic pulp necrosis [21].

The clinical signs and symptoms of inflammatory internal resorption were different depending on the stage of the resorptive process. In the early and active stages of this resorption there were no symptoms or clinical signs. During the clinical examination, an asymptomatic course was found in 40% of cases and root resorption was detected accidentally during radiographic study. In 46.7% of cases, progressive clinical manifestations were pain, tooth discoloration, tenderness over apex, etc. Abbott P. [15] assumes, that the internal resorption of the hard tooth tissues progresses only when the pulp is vital. As soon as the amount of intracanal infection exceeds compensatory

functions, the vascular-nerve bundle damages and apical periodontitis develops. Complete pulp removal or pulp necrosis stops the resorptive process [22].

Radiography is mandatory for the diagnosis of internal resorption, which reveals a well-defined symmetric oval radiolucent expansion of uniform density that balloons out of the pulp chamber or root canal [18]. Thomas P. et al. [4] investigated that in the teeth with one root canal, internal resorption begins as a symmetrical lesion in the coronal pulp, in multi-rooted teeth with a wide pulp chamber, it starts from one part of the pulp chamber and spreads locally into the surrounding dentin. Scientists have developed radiological criteria for the diagnosis of internal resorption, among them, in addition to the above-mentioned radiological features, the movement of the resorptive lesion relative to the root canal: in internal tooth resorption, when the radiographs are taken at different angles, the radiolucent defect moves together with the canal; in external tooth resorption, the radiolucent defect moves outside of the canal. Internal resorption has a uniform expansion of the canal space with normal bone structure, whereas external resorption has irregular margins with changes in the surrounded

bone, and the canal can often be visualized through a radiolucent area [17, 21].

From the results of our research, it can be noted that internal resorption is most often localized in the middle and apical thirds of the root canal. Vier F. V. & Figueiredo J. A. P. [24] investigated that radiologically internal resorption occurring apically is difficult to diagnose; a serious problem is the detection of resorption lesions on the facial or lingual or palatal aspects. Clinicians found that in the root canals with periapical lesions, about 50% had internal apical resorption in more than half of the area. That is why, for the diagnosis of internal apical resorption, exclusion of external cervical resorption, as well as in order to determine the degree and presence of any perforation of the root canal wall, high-resolution CBCT with a small field of view (FOV) is used (American Association of Endodontists/American Academy of Oral and Maxillofacial Radiology, 2015) [6, 11]. CBCT was used by us as an adjunct to, and not as a substitute for, conventional radiography after clinical and conventional radiographic examination following the recommendations of the European Society of Endodontics (2019) for the use of CBCT in endodontics.

CONCLUSIONS / ВИСНОВКИ

Early diagnosis, elimination of the cause, timely management of root resorption are mandatory for tooth preservation. The main method of diagnosis of internal tooth resorption is radiographic, as the process can proceed without subjective painful sensations. One of the radiological criteria of pathological tooth root resorption is a change in the

internal configuration of the root canal. The leading role belongs to CBCT study, because three-dimensional visualization can assess the degree of destruction of hard tooth tissues, the topography of the resorption of hard dental tissues and adjacent bone tissue. When evaluating CBCT images, special attention should be paid to the apical part of teeth with chronic forms of apical periodontitis.

PROSPECTS FOR FUTURE RESEARCH / ПЕРСПЕКТИВИ ПОДАЛЬШИХ ДОСЛІДЖЕНЬ

In the future, the results of treatment the patients with internal root resorption will be presented, as well as the issue of clinical manifestations, diagnosis and management of other types (external and combined) tooth resorption.

CONFLICT OF INTEREST / КОНФЛІКТ ІНТЕРЕСІВ

The authors declare no conflict of interest.

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AUTHOR CONTRIBUTIONS / ВКЛАД АВТОРІВ

NG – work concept, design, writing the article, critical review of manuscript, final approval, correspondence with journal.

AP – data collection and analysis, statistical analysis and interpretation of results, critical review.

OC – review of literature and manuscript preparation, data collection and review of manuscript.

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